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EPA'S ANALYSIS OF AIR DRILLING AT WIPP

January 27, 1998

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EXECUTIVE SUMMARY

Air drilling is a process in which air or another gas is used instead of water-based mud as a circulating fluid and is used for removing cuttings from a hole during drilling. Technical, economic, and safety considerations generally determine the choice of drilling method. Compared to mud drilling, air drilling has the principal advantages of reduced formation damage in some production zones, potentially higher penetration rates, and easier penetration of hard rocks. The principal disadvantages of air drilling include a minimal capability to control high formation pressures, a minimal ability to prevent caving of borehole walls in weak formations, and a limited ability to cope with inflows from water-producing formations. Under favorable conditions, the advantages of air drilling may reduce costs and make it a preferred technology. Under less favorable conditions, the use of air drilling is precluded by both technical and economic considerations.

Air drilling has been identified in public comments as a scenario which should be considered in the WIPP performance assessment. Public comments raised the following issues: the air drilling scenario was not included by the Department of Energy (DOE) in the Compliance Certification Application (CCA); air drilling technology is currently successfully used in the Delaware Basin; air drilling is thought to be a viable drilling technology under the hydrological and geological conditions at the WIPP Site; and air drilling could result in releases of radionuclides that are substantially greater than those considered by DOE in the CCA. This report addresses these issues.

EPA has examined well records, talked to industry contacts, and reviewed public comments and has determined that air drilling through the Salado and Castile Formations is not a current practice in the Delaware Basin. The Agency has determined that because of operational difficulties, air drilling is currently only rarely used in the Delaware Basin and little evidence has been found of any use in the vicinity of the WIPP Site. The Agency has therefore concluded that under the terms of its requirements in Sections 194.32 and 194.33 for analyzing drilling events consistent with current practice at the time the CCA was prepared, and for analyzing the effects of activities in the vicinity of the WIPP, air drilling does not need to be included in the WIPP performance assessment.

Nevertheless, EPA conducted a technical analysis of the consequences of air drilling. EPA's technical assessment of spallings associated with a hypothetical air drilling event indicates that only limited volumes of waste material would fail and contribute to releases. The amount of spall from air drilling calculated for conditions of high pressure in the repository indicate that the volume of releases would be within the range estimated for drilling with mud (0.5 m^3 to 4.0 m^3).

1. INTRODUCTION

This document summarizes EPA's analysis of the potential for using air drilling technology at the Waste Isolation Pilot Plant (WIPP) during the 10,000-year period of regulatory concern. Air drilling was not considered in the U.S. Department of Energy's (DOE's) Compliance Certification Application (CCA) as a potential drilling technique. Members of the public have raised issues concerning air drilling, indicating that it may be appropriate to include this drilling technique in performance assessment. Commenters stated that air drilling technology is currently successfully used in the Delaware Basin, appears to feasible, and could result in radioactive releases that are substantially greater than those considered by DOE in the CCA. EPA has examined this drilling method because it is possible that if air drilling techniques were used instead of the mud drilling techniques assumed by the DOE, spallings releases may potentially be different than those documented in the CCA. This report summarizes the Agency's investigation of air drilling and its associated issues, and presents the Agency's conclusions regarding the potential for air drilling at WIPP.

The Agency's regulatory concern is based on the extent to which the air drilling scenario meets the requirements of Sections 194.32 and 194.33. The Agency also reviewed the technical and economic issues of deep drilling with air under the conditions at WIPP, the safety issues associated with the marginal ability of the method to deal with high formation pressures that could be encountered in a Castile brine pocket at WIPP, and whether inclusion of the air drilling scenario in WIPP performance assessment would result in substantially greater spallings releases than are presently considered in the CCA.

This report is presented in seven sections. Following this introduction, a review of current air drilling practices is presented in Section 2. Section 3 presents a review of the Agency's requirements and guidance for assumptions regarding future drilling technologies in the CCA. The current use of air drilling in the Delaware Basin and vicinity of the WIPP Site is described in Section 4. Technical, economic, and safety issues regarding air drilling at the WIPP Site are described in Section 5. The results of Agency modeling of spallings releases during air drilling at WIPP are presented in Section 6, with more detailed discussion of this modeling in Appendix A to this report. The Agency's conclusions regarding the potential for air drilling at WIPP are presented in Section 7.

2. REVIEW OF AIR DRILLING PRACTICES

This section presents an overview of current air drilling practices. The focus of this discussion is on the use of air drilling under the geological and hydrological conditions in the Delaware Basin. Much of the information in this overview was taken from documents prepared by the Gas Research Institute (GRI 1995) and from *Air and Gas Drilling Manual* (Lyons 1984).

Air drilling refers to a drilling process in which air or another gas is used instead of water-based mud as a circulating fluid for removing drill cuttings from the hole. Air drilling technology was

developed over 40 years ago and has been successfully used to drill a wide variety of wells in the United States. Although initially used predominantly for shallow and environmental applications, air drilling is now also used by the oil and gas industry for deeper wells in two primary ways: as a means to minimize formation damage in some production zones, and as a means to quickly drill through formations between the ground surface and target depth.

Air drilling uses a drilling rig and drill string that have many similarities to those used in conventional mud rotary operations. The primary differences are in the type of drill bit and circulating fluid, and in the use of air compressors, associated valving, and other specialized uphole and downhole equipment. Air or other gases or gas mixtures are pressurized at the surface with a compressor and booster system and injected into the drill string pipe. Typically, the pressurized air travels down the hole through the drill string, passes through the drill bit, and returns to the ground surface carrying the drill cuttings in the wellbore annulus. As the air passes through nozzles at the drill bit, its velocity increases, allowing it to clean the bottom of the hole and to also cool the bit. In some applications, the air also provides the energy needed to turn rotary bits or to activate percussion hammerdrills. At the ground surface, the cuttings are typically discharged through a blooey line (gas bleed-off line) to the flare pit where flammable formation gases are burned off.

Technical, economic, and safety considerations determine the choice of drilling method. Compared to mud drilling, air drilling can have the advantages of minimizing formation damage in production zones, reducing lost circulation problems, increasing penetration rates, facilitating penetration of hard rocks, forming straighter holes, minimizing drill mud costs, and allowing cleaner operating conditions. Air techniques are primarily used in drilling production wells where the geology is well known, the rock is stable, water inflows are not significant, and the formations being drilled are not highly pressurized. Under favorable conditions, the advantages of air drilling can reduce costs by reducing rig operating time and thus can make it a preferred technology. Air drilling to depths of more than 19,000 feet has been successfully accomplished in areas where geologic and hydrologic conditions were favorable.

The disadvantages of air drilling limit its use at locations where conditions are less favorable, often not because of technical limitations but due to economic considerations. Under less favorable conditions, the following disadvantages can raise the cost of air drilling to the point that it is no longer economical:

- Formation pressure control is minimal because there is little or no drilling fluid pressure to contain blowouts and, therefore, drilling is limited to geologic regions where reservoir pore pressures are low.

- Drilling is limited to geologic regions where the rock formations are stable because there is little or no drilling fluid pressure to support the borehole wall and prevent sloughing or “squeeze-in.”

- There is a limited ability to cope with significant volumes of water entering the annulus from water-producing formations. The energy required to remove the water reduces the energy available to remove drill cuttings and reduces the efficiency of the drilling process.

- The drill pipe can experience high wear due to abrasion from cuttings moving up the annulus.

- The air provides little or no cushioning of the drill string during handling mishaps.

- There is great danger of downhole fire when drilling into formations containing flammable gases unless the air is replaced by a gas that is not combustible under downhole conditions.

- Fluid handling equipment must also be available on site to place and cement casing, which can require a duplication of equipment and a time-consuming switching back and forth from air- to mud- to air-filled boreholes.

Because of its disadvantages, air drilling is not typically used at locations where high formation pressures are likely to be encountered, where the rock is not self supporting and may cave or squeeze into the borehole, where high water inflows may be encountered, and where casing requirements necessitate frequent switching between air- and mud-filled boreholes. Air drilling technology is also not typically suited for exploratory drilling due to the risks associated with the minimal ability of air to control blowouts and to deal with weak formations and large water inflows when drilling into areas with poorly understood geologic and hydrologic conditions.

Air drilling is typically least expensive and most advantageous when performed in stable formations without the use of fluid additives. A water mist and foaming agents (surfactants or soap) can be added to the air stream to assist with removal of formation water and reduce the risk of downhole fire. Increasing the compressor and booster system capacity can also help to maintain drilling rates when encountering wet formations. Wells penetrating formations containing natural gas can be drilled using gases other than air to reduce the risk of downhole fire. Air drilling and air/foam technology is now commonly used to complete wells in a production zone or to re-work or re-stimulate an existing well. Although technologies are available to deal with a variety of adverse downhole conditions, such complications reduce the cost advantages that can be associated with air drilling. The cost savings potentially realized through use of air drilling are highly dependent on site specific conditions.

3. REQUIRED DRILLING ASSUMPTIONS FOR THE WIPP CCA

In the CCA DOE identified that the current practice for drilling in the Delaware Basin was to use mud as the drilling fluid. The borehole development processes are described in great detail in the CCA (Appendix DEL-5). As stated in Appendix DEL.5.1.3: “There are a variety of drilling fluids used in Delaware Basin drilling. Most rotary drilling operations use saturated brine (10 to 10.5

pounds per gallon) as a drilling fluid until reaching the Bell Canyon Formation, where intermediate casing is set." However, public commenters have stated that air drilling is a drilling technique that could be used.

EPA has reviewed the regulatory requirements that have bearing on whether air drilling should be included the WIPP performance assessment. They are 40 CFR Part 194 (61 FR 5224, Feb. 9, 1996) sections 32 (scope of performance assessments) and 33 (consideration of drilling events in performance assessments), and the New Mexico Oil Conservation Division (NMOCD) Order R-111-P. Section 194.32(a) requires that performance assessments include drilling that may affect disposal system during the regulatory time frame while section 194.33(c)(1) directs DOE to assume future drilling practices are consistent with practices at the time the certification application was prepared.

NMOCD Order R-111-P describes requirements for potash mining and oil and gas operations within the "potash area" in Eddy and Lea Counties, New Mexico. Because the WIPP Site is within the prescribed "potash area," the requirements of the Order apply to drilling in the vicinity of WIPP. Order R-111-P became effective in April 1988. It defines the boundaries of the potash area and applies to both private and Bureau of Land Management (BLM) lands in southeastern New Mexico. Subpart D of the Order requires that a surface casing string must be cemented into the basal Rustler Formation before drilling into the underlying Salado Formation and that a salt protection casing string must be cemented into the salt section before drilling into the underlying oil or gas production zone. Additionally, Subpart E of the Order requires that drilling in the area must be accomplished using salt saturated water as the drilling fluid using additives such as mud, if needed. These requirements protect the salt section from dissolution by drilling fluids, by water inflows from overlying formations (particularly from the Culebra Dolomite), and during oil or gas production. The requirements for multiple casing string installations and for cementing the casing strings to the ground surface reduce the economic advantage of air drilling because of the cost and delay of switching the borehole fluid several times from air to mud and back to air each time a casing string is set. If the hole were air drilled, the drilling fluid would probably have to be changed to mud to place and cement the casing, the mud would have to be displaced by water prior to and after cement drill-out for testing purposes, and the water would then have to be displaced by air to continue drilling. Therefore, NMOCD Order R-111-P effectively eliminates the use of air drilling in the potash area, including the WIPP site for the present and near-future.

To constrain speculation about future drilling practices in the compliance application, the Agency stipulated in 40 CFR 194.33(c)(1) that performance assessment consider only the present day drilling practices and technology occurring within the Delaware Basin: "Performance assessments shall document that in analyzing the consequences of drilling events, the Department assumed that: Future drilling practices and technology will remain consistent with practices in the Delaware Basin at the time a compliance application is prepared. Such future drilling practices shall include, but shall not be limited to: the types and amounts of drilling fluids; borehole depths, diameters, and seals; and the fraction of such boreholes that are sealed by humans." EPA intended this provision to refer to commonly used drilling procedures used at the time DOE submitted its CCA

or within several years before the submission of the CCA, rather than referring to every single practice used in the Delaware Basin. As discussed in section 4 of this report, EPA has determined that the use of mud as the drilling fluid is the current practice for drilling through the salt section (the Salado and Castile Formations) and that air drilling through the salt section is not consistent with drilling practices in the Delaware Basin. Thus, DOE properly excluded air drilling through the salt section from consideration in the WIPP performance assessment.

4. CURRENT USE OF AIR DRILLING IN DELAWARE BASIN AND VICINITY OF WIPP

EPA reviewed Delaware Basin well records, talked with drilling industry contacts, and reviewed public comments in order to ascertain the prevalence and use of air drilling.

Well File Search

The EPA has performed a random analysis of 203 deep wells within the Delaware Basin, examining the New Mexico Oil Conservation Division well files for Lea and Eddy Counties. Sections within each township and range in the New Mexico portion of the Delaware Basin were selected randomly, and wells within each randomly selected section were also randomly chosen for examination. The analysis excluded wells within the Potash Exclusion Zone and wells drilled prior to 1950. These wells were excluded so that wells precluded from air drilling by regulation were not examined, and so that the analysis focused on those wells drilled within the Delaware Basin when the use of air drilling was greatest. Air drilling is a relatively new technology and was not widely used on a national basis prior to 1950.

Results of EPA's analysis indicated that the 203 drilling records examined showed only one potential incident of air drilling through the salt section. This well, the George H. Williams Federal Johnson No. 1, was drilled in T24S R34E, Section 13, and is approximately 18 miles southeast of the WIPP site. The well was drilled in 1958, and the only indication of air drilling is a sundry note on a June, 1958 record stating that the operator intended to drill out of the 8 5/8 inch surface casing using air to the Delaware Mountain Group (the casing was set from ground surface to the top of the salt section). There are no data that indicate whether this well was indeed drilled as proposed.

EPA notes that there is evidence to indicate that wells were occasionally "dry drilled" through the Rustler formation when mud circulation was lost (e.g., Oscar State well in T24S, R29E, section 36). However, no wells examined in the 203 well EPA survey were "dry drilled" through the salt section. Attachment 1 presents a table with an example of the information EPA gathered for each well that was examined using field records.

EPA performed statistical analysis of data obtained to assess the probability of air drilling. EPA used the standard Clopper-Pearson confidence bound to determine the probability of air drilling. Using a 95% confidence level and assuming that the total number of wells is much larger than a sample size of 200 wells and that one of 200 wells was air drilled, the number of air drilled wells

in the New Mexico Delaware Basin would be expected to be less than 2.34% of the total wells drilled. EPA concludes that these data indicate air drilling is a rare occurrence in the Delaware Basin.

Seven Well Analysis

EPA also examined wells not identified in the random survey, but suspected of having been drilled using air. EPA identified these wells through public comments and through a DOE survey of well records (see Kirkes, Ross, 1998; Docket A-93-02, Item IV-G-8). EPA is aware of seven wells in the New Mexico portion of the Delaware Basin that may have, at some point, been drilled using air or were "dry drilled." (Dry drilling is drilling without adding any drilling fluid, intentionally.) Of these wells, three may have been "dry drilled" or air drilled into or through the salt section. These three wells are the Lincoln Federal No. 1 (T21S, R32E, Section 26), South Culebra Bluff Unit No. 4 (T23S, R28E, Section 23) and Amoco Federal No.1 (T23S, R28 E, Section 11). Operators of two of the four remaining wells (South Culebra Bluff Unit No. 3, T23S, R28E, Section 23, and Amoco Federal No. 3, T23S, R28E, Section 11) used air in the completion interval after mud was used to drill through the salt section. Air drilling was attempted in the remaining two wells, the Thorn and Grauten Russell Federal No. 1 (T26S, R32E, Section 20) and Federal Unit B.E. No. 1 (T24S R34E, Section 4), but the drilling fluid had to be switched to mud prior to drilling the salt section.

Air drilling was the intended drilling medium for the South Culebra Bluff Unit No. 4. In the Amoco Federal No.1 well, air drilling was apparently to be initiated in the formations above the salt section to preclude lost mud circulation, and the salt section was then to be drilled with air. Both of these wells were started in 1979, with the Amoco Federal No. 1 completed the same year and the South Culebra Bluff Unit No. 4 completed in 1980. The Amoco Federal No. 1 was later re-entered (apparently using a mud system) and recompleted. Available file information indicates that drilling of the Lincoln Federal No. 1 well was initiated using a mud system, but mud circulation was lost in the upper Salado Formation, approximately 1290 feet below ground surface. This hole was then dry drilled into the salt section to approximately 1790 feet, after which the hole was apparently drilled using air to the top of the Delaware Mountain Group. (This is supported by statements in wells files that indicate air was circulated while casing was set to the top of the Delaware Mountain Group). In this instance, air was not the intended drilling media, and was apparently used in an attempt to continue drilling when other methods (mud, dry drilling) failed. The Lincoln Federal No. 1 was drilled in 1991.

The geology of the South Culebra Bluff Unit No. 4, Amoco Federal No. 1, and Lincoln Federal No. 1 wells was examined by EPA to determine whether site characteristics in the area of these wells are different than those at WIPP. In the case of the Amoco Federal No. 1 and South Culebra Bluff Unit No. 4, the Salado and Castile formations are both present, but the Salado is approximately 1000 feet thinner than at WIPP (Snider, 1966, A-93-02, II-G-01, Ref. No. 598). As a result, the Salado and Castile formations are closer to the earth's surface in this area than they are in the vicinity of the WIPP. The overlying siliciclastic section (including the Rustler Formation) is also dramatically thinner in the South Culebra Bluff area than at the WIPP. In

addition, the wells are located quite near the Pecos River, which could affect the local hydrologic system.

The Lincoln Federal No. 1 is located approximately 1000 feet from the Capitan Reef and the Delaware Basin boundary. The Capitan Reef is a major aquifer outside the edge of the Delaware Basin, and could affect local hydrologic systems. Geologic data (e.g., Borns and Schaffer, 1985, A-93-02, II-G-1, Ref. No. 78, and Adams, 1944, A-93-02, II-G-1, Ref. No. 1) indicate that the Castile Formation thins in the Lincoln Federal No. 1 area, , even though the Castile generally tends to thicken around the eastern basin margin. Well logs and drilling records show that both halite and anhydrite are present in strata at the Lincoln Federal area, indicating that although stratigraphy may be somewhat different, major lithologies found in the WIPP area are present at this location. One different feature observed on the Lincoln Federal well log was an approximately 300 ft zone at the top of the Salado and base of Rustler that exhibited high neutron porosity and was identified in drilling records as containing a 2 ft thick lost circulation zone. Both the Amoco Federal No.1/South Culebra Bluff Unit No. 4 and Lincoln Federal areas differ from the vicinity of the WIPP in that they are relatively close to major hydrologic features that could impact stratigraphic characteristics of the rock units (i.e., could create more dissolution-related higher porosity zones that could cause lost circulation and require initiation of air/dry drilling).

Drilling records for these seven wells did not contain extensive discussion of the air drilling process. EPA's determination of potential air drilling through the salt section for the first three wells listed above was based, for example, on single statements within entire well files that imply air drilling was used, on mud plans which indicate that the driller planned to drill with air in the salt section, or on inferences that air was circulated in a hole while casing was set through the salt section.

EPA Survey of Drilling Service Suppliers

EPA contractor staff contacted suppliers of drilling services, who provide well data to the petroleum industry in New Mexico and Texas. EPA initiated this as a method to determine the extent to which air drilling is currently used in the Delaware Basin. The following database suppliers (with telephone numbers) were contacted in late 1997.

- Hydrocarbon Production Data Inc. in Texas (800-282-4245; 512-418-8845)
- Petroleum Information Inc. in Colorado (303-595-7500)
- Lasser Inc. in Texas (817-922-8100)
- Independent Association of Drilling Contractors in Texas (281-578-7171)
- Drilling Records Inc. in Colorado (303-694-3636)

- Independent Producers Association, Mountain States, through Gas Research Institute Library in Colorado (303-575-9030)

None of the database suppliers could provide information on the type of drilling or drilling fluid used, and a database search for air drilling indicators was not found to be possible. In view of the lack of a suitable electronic database, individuals from the drilling industry were contacted as another method to aid the Agency's understanding of the use of air drilling in the Delaware Basin. Some of these contacts were individuals already known to the Agency and others were selected by consulting major oilfield service companies with offices in New Mexico and west Texas. Additional contacts were identified by consulting the 1997 Hart's Permian Basin Yellow Pages for local contractors and suppliers. No preference was made in selecting the industry contacts, and volunteered information and names of other contacts were accepted from all individuals.

EPA contractor staff contacted the following 25 individuals from November of 1997 through January of 1998. EPA contractors asked if they had knowledge of any wells drilled using air or gas within 20 miles of the WIPP Site, wells drilled within the Delaware Basin, or wells drilled under conditions similar to those found at WIPP.

- **Steve Ripley of Halliburton Energy Services in Artesia, New Mexico** said that he has drilling-related experience in the Delaware Basin. He reported that lost circulation problems were common north of Carlsbad and therefore some wells have been drilled with air until excess water was encountered. He said that Devon Energy has drilled a number of wells using air north of Carlsbad [outside of the Delaware Basin]. To his knowledge, there were no wells drilled with air east of Carlsbad or near the WIPP Site.

- **Lalo Garcia of Davis Tool in Hobbs, New Mexico** stated that most wells drilled with air in southeast New Mexico only use air technology to achieve underbalance in the production zone. Standard mud rotary is used to set casing and penetrate to depth. He said that quite a few wells have been air drilled southwest of Carlsbad toward El Paso and Del City, Texas, and north of Carlsbad near the Loco Hills (approximately 30 miles north of WIPP outside the Delaware Basin). He had no knowledge of air drilled wells near WIPP. He indicated, in his opinion, that anything deeper than 11,000 to 13,000 feet would take far too much air to lift any water if it was encountered.

- **Dowell Schlumberger, Inc. Completion Services in Monahans, Texas** was contacted regarding air drilling or completion activities in the Permian or Delaware Basins. Tim, an operator in the shop, indicated that most of their air-related work was currently in the vicinity of Sonora, Texas, and was being performed for Burlington Resources and UPRC (Sonora is in Sutton County, Texas, approximately 150 miles east of the Delaware Basin). To his knowledge, there were no air drilling activities west of Monahans, Texas [in the Delaware Basin].

- **Larry Lucky of UPRC in Fort Worth, Texas** indicated that UPRC was using air drilling extensively in the Permian Basin near Ozona, Texas (Ozona is in Crockett County, approximately 100 miles east of the Delaware Basin). He stated that UPRC has not branched out with air drilling any farther to the west and was not aware of anyone else using air drilling farther west than Crockett County [in the Delaware Basin].

- **Phil Stinson of O'Brien-Goins-Simpson & Associates, Inc. in Midland, Texas** was contacted regarding drilling technologies in the Delaware Basin. Mr. Stinson indicated that he was familiar with air drilling but could not "think of any air drilling in the Delaware Basin because of sloughing formations and too much water influx." He indicated that he recalled some air drilling in salt years ago in west Texas but could not provide any details.

- **Ray Peterson of Peterson Drilling Co. in Midland, Texas** indicated that air drilling has met with limited success in the Delaware Basin in an effort to "save a string of casing," but he did not have any specific details.

- **Mark Henkhaus, District Manager of the Texas Railroad Commission in Midland, Texas** indicated that he believed that Burlington Resources has done air drilling in Reeves and Pecos Counties, Texas. His recollection was that air drilling had been tried southwest of Ft. Stockton, Texas, and that a lot of air drilling was taking place east of Ft. Stockton [outside of the Delaware Basin].

- **Jim Ward, Consultant to Burlington Resources in Midland, Texas** indicated that Burlington Resources has made attempts to drill with air in the Delaware Basin. Wells drilled last year by Nabors Drilling south of Fort Stockton were attempted with air but watered out before a depth of 4500 feet was attained. These wells were not drilled through any salt and were in an overthrust near the edge of the basin. Mr. Ward indicated that air is being evaluated for drilling to the Bone Springs Formation and other pay zones below the Delaware Group, after an intermediate string is set with a mud rotary rig. Mr. Ward also indicated that the sands of the Delaware Group often yield too much water to allow economical air drilling. He also noted that Burlington Resources uses air drilling to the east of the Delaware Basin and is “trying to find new places to apply air drilling technology because new equipment is available.” Air drilling technology is improving at a relatively rapid pace and new larger rigs are capable of handling more water influx than in the past. He noted that there have been occasions where the water production rate was sufficiently great that air drilling became impractical due to a combination of drilling complications and water disposal costs.

- **Dan Stoelzel of Bass Enterprises in Midland, Texas** was contacted and asked if Bass was doing air drilling in New Mexico or Texas. He indicated that based on his knowledge Bass is not drilling with air in the Delaware Basin for several reasons. These include a lack of economic advantage, differing pressure horizons in a single borehole intersecting depleted, injection and naturally pressurized zones, along with the potential for water

influx. Discussions with his supervisor, Mr. David Bledsoe of Bass Enterprises, confirmed this and Mr.Bledsoe indicated that Bass Enterprises is not and has no plans to drill with air in southeastern New Mexico. Mr. Stoelzel indicated that Bass is using air drilling in south Texas near Ozona and Sonora [outside the Delaware Basin]. He further indicated that since most pay horizons in the vicinity of the WIPP Site often require hydraulic fracturing during completion, the use of air drilling to minimize near-wellbore damage would be of less importance.

- **Floyd Abbott of Abbott Brothers in Hobbs, New Mexico** was contacted regarding air drilling in southeastern New Mexico. He stated that Abbott Brothers installs rat-holes and conductor pipe. He indicated that in southeast New Mexico, it is necessary to mud-up when drilling with air to a depth of 50 or 60 feet. He also indicated that in as many as 1 out of 10 drilling events, air drillers will encounter "sugar sand" within 100 feet of ground surface, which makes air drilling a problem. He stated that his company has been in the area for a long time, that many air drillers have problems drilling through salt, and that redbed clays present in the area will swell and cause drilling problems when water is contacted during air drilling.

- **Udie Morgan of Auger Air Drilling in Hobbs, New Mexico** indicated that Auger only drills ratholes and installs conductor casing to 80 or 100 feet below ground surface. In the New Mexico portion of the Delaware Basin, they occasionally run into water within the top 80 feet and must mud-up.

- **Matt McGee of Patterson Drilling in Midland, Texas** indicated that Patterson Drilling is very active with air drilling and that they have 20 wells now being drilled in the Valverde Basin. He believed that water was relatively plentiful in the Delaware Basin which makes air drilling difficult. He also indicated that in the vicinity of the Delaware Basin "air drilling can be useful to drill though porous reef zones [the Capitan Reef at the Basin margin] that cause lost circulation problems."

- **Brent Sanders of Nabors Drilling in Midland, Texas** indicated that Nabors Drilling had a two well drilling package with Burlington Resources southwest of Ft. Stockton Texas in late 1997. He indicated that, to his recollection, air drilling was not used exclusively and that they had to mud-up when drilling both wells.

- **Jim Slay of Patterson Drilling in Midland, Texas** indicated that Patterson Drilling is very active with air drilling. Mr. Slay recalled that Patterson supplied services to Burlington Resources during 1997 to drill wells southwest of Toyah, Texas. Patterson Drilling used a mud rotary rig, but Mr. Slay did not recall any air drilling. Mr. Slay also indicated familiarity with drilling activity in the area and was not aware of "much air drilling in Reeves or Pecos County, Texas because of concerns with too much water."

- **Mike Johnson of Weatherford Enterra in Midland, Texas** stated that several major oil/gas exploration/production companies, including Conoco, Chevron and Texaco, did a lot of air drilling near Artesia (approximately 30 miles north of Carlsbad [outside of the Delaware Basin]) but experienced significant problems with water inflow. Air drilling is much more prevalent in southwest Texas. In fact, southwest Texas is where a majority of the air drilling equipment is located. He believed that a well was air drilled south of Monahans, Texas (Ward County) and stated that most of the air drilling in the area that he was aware of occurred 60 to 100 miles south of Imperial, Texas [outside the Delaware Basin].

- **Bill Maxwell of Weatherford Enterra in Odessa, Texas** stated that he was not an expert in air drilling. Although he was familiar with the technology, his specialty was drilling with foam. However, he did state that he was not aware of anyone drilling with air in the Delaware Basin, and that he would have heard of it if it was occurring.

- **David Griffin of Symbol, Inc. in Midland, Texas**was not aware of any specific wells drilled with air near the WIPP Site. He mentioned that a new mining venture, possibly called Freeport, was using air to drill test wells between Carlsbad and Pecos, Texas.

- **Conrad Lee of Davis Tool in Hobbs, New Mexico** stated that the Cat Claw region west of Carlsbad is suitable for air drilling. He said that air drilling is not suitable east of Carlsbad due to excessively wet formations. Air drilling has been used with limited success near Del City, Texas (approximately 45 miles southwest of Carlsbad) but excessive water flow is often encountered. Based on his experience, he stated that more than 10 barrels of water per hour (7 gpm) would kill most air drilling jobs.

- **Keith McKamey of New Mexico Oil Conservation Division (NMOCD) District Office in Artesia, New Mexico** indicated that as an experienced geologist and regulator, he is not aware of any wells that have been air drilled in the New Mexico portion of the Delaware Basin; however, he also stated that his knowledge is not comprehensive. In a meeting with the Artesia Office NMOCD Field Inspectors, he inquired if any were aware of air drilling activities in the Delaware Basin. Mr. McKamey reported that the inspectors were not aware of any air drilling activities in the basin or around WIPP. The inspectors were familiar with air drilling being used by Louis Dryfus to install wells near the Marathon gas plant northwest of Carlsbad and that some of those wells ran into water at unknown depths. He attributed the apparent lack of air drilling in the basin to stability problems in unconsolidated formations and excessive water influx. He noted that at WIPP itself and in the small "potash area" around WIPP, air drilling is currently prohibited by regulation. He stated that air drilling in southeastern New Mexico typically involves drilling through the San Andres Limestone in areas not prone to excessive water and where boreholes are sufficiently stable.

- **Paul Kautz of New Mexico Oil Conservation Division (NMOCD) District office in Hobbs, New Mexico** was not aware of air drilled wells in the New Mexico part of the Delaware Basin and stated that air drilling was not practical because the lithology encountered in the Delaware Basin is not conducive to drilling with air.

- **Angel Salazar of United Drilling in Roswell, New Mexico** stated that in 1982 or 1983 he had attempted to air drill north of Highway 31 near Loving, New Mexico, at the edge of the Delaware Basin. Although the total planned depth of this well was 2800 feet, the well watered out at 1800 to 1900 feet and had to be switched to a mud system. He indicated that potash wells drilled near WIPP used a mud system due to water influx. He stated that most air drilling in southeast New Mexico is conducted near Roswell and Artesia to avoid lost circulation problems.

- **Joseph Lara of U.S. Bureau of Land Management (BLM) in Carlsbad, New Mexico** stated that, to his knowledge, there was no air drilling within the Delaware Basin or in the vicinity of WIPP. The only air drilling he was aware of was done northwest of Carlsbad, New Mexico [outside of the Delaware Basin]. These wells are drilled with air for the upper 1000 feet, casing is set, and then the system is converted to a mud-based drilling fluid.

- **Alexis Swoboda of U.S. Bureau of Land Management (BLM) in Roswell, New Mexico** stated that she was unaware of air drilling technology being used within the Delaware Basin, although she thought Marathon had done some drilling with air northwest of Carlsbad, New Mexico [outside of the Delaware Basin].

- **Don Glass of U.S. Bureau of Land Management in Roswell, New Mexico** stated that, to his knowledge, air drilling technology was not currently being used in the Delaware Basin, but he recalled that it had been used at some time in the past.

- **Michael Amos of M-I Air Drilling Services in Ft. Stockton, Texas** stated that in 1981 or 1982 he used air technology near Loving, New Mexico, to drill the lower part of an 8200 foot borehole into the Bone Springs Formation. The upper part of that hole was drilled with mud and air drilling commenced at a depth of about 5000 feet. Mr. Amos also stated that he had recently completed a deep well with air for Burlington Resources north of the Glass Mountains in Texas without difficulty, but that the well had not encountered the Salado Formation. He was also aware of air drilling programs proposed by Conoco, Sonat, and Bonneville Energy northwest of Carlsbad [outside of the Delaware Basin].

In summary, drilling contractors, tool rental companies, air drilling consultants, and state officials have been contacted regarding the use of air drilling near the WIPP Site or within the Delaware Basin. These contacts indicated that, almost exclusively, air drilling in the Delaware Basin was found to have been done after the hole was drilled and the completion casing was set using a mud circulation system. At that time, air or foam may have been used to stimulate the well's

production, disposal, or recompletion zone, but not for the actual drilling. Air drilling was also used to drill production zones after having drilled the upper part of the well with mud. This use of air was reported in a well near Loving, New Mexico. Furthermore, air drilling was not done in the vicinity of the WIPP. Some wells were drilled with air north and southwest of Carlsbad until excess water was encountered; however, these wells were not in the Delaware Basin. Geologic and hydrogeologic conditions can change abruptly within and beyond the Capitan Reef, which defines the edge of most of the basin, and these areas were therefore explicitly excluded from the Delaware Basin in the Rule (see 40 CFR 194.2).

Industry contacts indicated that air drilling is more prevalent outside the Delaware Basin where conditions are more favorable. For example, in locations that are more favorable for air drilling, there is less water inflow and there is no stratum with brine pockets such as the Castile. Much of this drilling occurs either outside or on the edge of the Delaware Basin where geologic and hydrogeologic conditions are different and, hence, are more favorable than at the WIPP Site. Air drilling is reported south of Monahans in Ward County, Texas, and south of Imperial in southern Pecos County, but neither of these areas are in the Delaware Basin. A single example of a well attempted to be drilled with air from the ground surface to total depth at or near the edge of the Delaware Basin in New Mexico was reported by Mr. Angel Salazar; however, this well could not be completed with air because of excessive water flows, and had to be completed with mud.

In addition, EPA contacted an industry representative to investigate the possibility that a well has recently been drilled using air near Fort Stockton, Texas. Mr. Michael Amos had indicated that he was currently drilling a well near Fort Stockton, using air. The area in question appears to be along the distant southeast margin of the Delaware Basin where the stratigraphic and structural characteristics of the Basin are different from that of the WIPP area. Mr. Amos indicated that while the well was installed using air, no salt section was encountered. Therefore, use of air to drill this well does not indicate that it is common practice to use air to drill through the salt section in the Delaware Basin.

Industry contacts indicated that the area between Carlsbad and the WIPP Site was not considered suitable for air drilling because of problems with excessively wet formations, problems with borehole stability, and high pressure brine reservoirs in the Castile Formation. Some successful air drilling from the ground surface was found to have occurred in the Texas portion of the Delaware Basin, but these holes were located at the margin of the Basin where geological and hydrological conditions are not the same as at the WIPP Site. None of the individuals contacted were aware of any oil industry related wells drilled within 20 miles of the WIPP Site using air technology for any purpose. In addition, New Mexico Oil Conservation Division (NMOCD) regulatory personnel in Hobbs and Artesia indicated that no wells have been drilled from the ground surface with air in the New Mexico portion of the Delaware Basin because of the problems cited above.

DOE Survey of Wells in Delaware Basin

DOE performed an independent well file search within the Delaware Basin and has provided the preliminary results of that search. DOE has indicated that as of January 26, 1998, its analysis has shown that of the 3349 wells examined in the Delaware Basin in New Mexico, 7 wells (0.2 %) showed indications of air drilling. (See Docket A-93-02, Item IV-G-8, letter from Ross Kirkes) This information supports EPA's conclusion that air drilling is an extremely rare practice in the Delaware Basin.

Impact of New Mexico Regulations

As previously noted, an Agency contact at the NMOCD District Office in Artesia, New Mexico, indicated that air drilling in the immediate vicinity of the WIPP Site is currently prohibited by regulation. The source of these regulations is NMOCD Order R-111-P which describes requirements for potash mining and oil and gas operations within the "potash area" in Eddy and Lea Counties, New Mexico. Because the WIPP Site is within the prescribed "potash area," the requirements of the Order apply to drilling in the vicinity of WIPP. The requirement to use salt saturated water as the drilling fluid essentially precludes drilling with any other type of fluid including air.

The Agency considered the possibility that the aforementioned scarcity of air drilling within the Delaware Basin could have been unrealistically influenced by this regulation if the "potash area" constituted a significant fraction of the total basin area. The prescribed "potash area" covers about 450 square miles, primarily around and to the north and west of the WIPP Site. The Delaware Basin as defined in the Agency's WIPP Compliance Criteria Rule (see 40 CFR 194.2) covers an area of about 8,800 square miles, and the "potash area" therefore comprises only about 5% of this area. The Agency considers this fraction to be small and concludes that the restrictions on air drilling in NMOCD Order R-111-P are not a significant cause for the scarcity of air drilling in the salt section in the Delaware Basin. Rather, the lack of air drilling is more likely related to technical and economic considerations.

Examination of drilling records and discussions with industry contacts indicate that air drilling through the salt section in the Delaware Basin is not "common practice." Further, there is no indication that air drilling is *currently* used in the New Mexico portion of the Delaware Basin, since all wells discovered to date that may have been initially designed to use air were drilled prior to the early 1980s. EPA does recognize that air drilling may be used as an alternative borehole installation method in very rare instances when site-specific or emergency conditions warrant its use, such as the 1991 Lincoln Federal No. 1 well. However, EPA concludes that air drilling is not "current practice" for drilling through the salt section in the Delaware Basin because of technical problems with wellbore stability and water inflows. In view of the scarcity of application of air drilling techniques under WIPP conditions and the scarcity of air drilling throughout the Delaware Basin in general, the Agency has concluded that air drilling does not require consideration in WIPP performance assessment because it is not current practice.

5. ISSUES REGARDING AIR DRILLING AT THE WIPP SITE

Upon reviewing the technical considerations for air drilling and the remarks of industry contacts, the Agency has concluded that air drilling through the salt section at the WIPP Site is unlikely under current technical and economic conditions because of three principal uncertainties: (1) the rock formations above the salt section may not have sufficient strength to stabilize the hole; (2) water inflows from the Culebra may be too large to allow economic air drilling; and (3) the potential for encountering high pressure zones in the Castile Formation makes air drilling risky. Although such problems may not occur in every hole, the uncertainty of success and the risk of failure appear to be sufficiently great that no current air drilling through the salt section has been confirmed in the vicinity of the WIPP Site.

Borehole instability due to weak strata was cited by several industry contacts as a reason why air drilling is not conducted in the New Mexico portion of the Delaware Basin. Several stratigraphic intervals exist in the Rustler Formation above the Salado that may slough or squeeze into an air drilled borehole, and are shown in Figure 2-9 of the CCA (Vol. I). Potential problems that may be encountered in formations above the Salado include:

- Santa Rosa: high permeability sandstone with the potential to contribute water
- Dewey Lake Redbeds: sloughing and borehole instability in this section is widely reported
- Rustler Formation: significant zones of plastic clayey silts are reported in the Tamarisk and unnamed Lower Member. Several feet to tens of feet may be present. In addition, potential paleosolution residues comprised of clay and silt may be present, and are reported in areas such as the upper and lower contacts of the Culebra member. Water inflow from both the Culebra and Magenta could occur. An approximately 20 ft zone of clayey silts lies between the Rustler and Salado Formations, the origin of which has been interpreted differently, but the characteristics are such (clay-rich zones) that they could contribute to borehole stability problems.

Large water inflows was the most commonly cited reason why air drilling is not conducted in the Delaware Basin, including the area around the WIPP Site. This reason was also given by representatives of NMOCD. Although air drilling technology is capable of handling higher water inflows by using larger air compressors, a driller's choice of drilling method is not necessarily governed by the limits of technology, but by cost feasibility. One industry contact cited an inflow of 10 barrels of water per hour (7 gpm) as the practical upper limit for most air drilling jobs in southeastern New Mexico. Applying the methodology presented by Lyons (1984 p. 109), at a surface elevation of 6,000 feet, an air drilling operation can potentially remove about 1,000 gallons of water per hour (about 17 gpm) while maintaining a drilling rate of 60 feet per hour with a compressor capacity of 2400 cfm (or 2005 scfm). Based on these inputs, a reasonable upper bound for water removal under current air drilling practice is therefore in the range of 10 to 20 gpm.

Water inflow into a hole drilled at the WIPP Site would originate primarily from the Culebra Dolomite. The transmissivity of the Culebra has been measured by the DOE in over 40 test holes drilled in the vicinity of the WIPP Site, and has been found to vary over four orders of magnitude from about 1×10^{-7} to 1×10^{-3} m^2/s with a single outlier at 1×10^{-10} m^2/s (see CCA Vol. XVIII Appendix TFIELD Table TFIELD-2). Most measured transmissivities greater than 1×10^{-5} m^2/s occur in the northwest quadrant of the WIPP land withdrawal area, although transmissivities greater than this value were measured in two wells (wells H-11 and DOE-1) in the southeast quadrant of the area. When a laterally extensive aquifer is penetrated by a borehole, the flow of water into the borehole will decline over time at a rate depending on the storativity of the aquifer. A mean storativity of 1×10^{-5} was determined by DOE from field measured values (see CCA Vol. XVIII Appendix TFIELD p. TFIELD-17). Using this storativity and assuming a bounding average inflow rate of 20 gpm, the transmissivity of the Culebra would have to be less than about 1×10^{-5} m^2/s for successful air drilling. This transmissivity approximates the midrange of the field measurements at and near the WIPP Site, and wells with measured transmissivities of 1×10^{-5} m^2/s or greater are found within the land withdrawal area to both the northwest and southeast of the repository site (see CCA Vol. XVIII Appendix TFIELD Table TFIELD-2). In addition, other wells in the area have transmissivities in the 10^{-6} to 10^{-5} m^2/s range, causing much of the WIPP Site to be borderline for feasible air drilling. The Agency considers these data to corroborate information cited above from industry contacts that the area around the WIPP Site is considered too wet for air drilling.

The final uncertainty affecting a driller's choice of air drilling at WIPP is the potential for encountering brine pockets in the Castile Formation exceeding hydrostatic pressures (see CCA Vol. I Section 2.2.1.2.2). Such pockets are known to be present in the vicinity of the WIPP and can result in well damage and loss of control, particularly if unexpectedly encountered when using air as the drilling fluid. Because of the problems and risk in controlling blowouts, air drilling is unlikely to be used for either exploration or production wells in areas such as the vicinity of the WIPP where pressurized brine pockets are present in the salt section. The Agency considers this observation to further corroborate the information cited above from industry contacts explaining why air drilling has not been successfully used near the WIPP or in the New Mexico portion of the Delaware Basin.

Deformation of the Castile Formation occurs within the Delaware Basin, and some of these features have associated brine pockets. Various origins for the deformational features have been proposed, including gravity sliding, gravity sliding and dissolution. While the origin of some features, such as Slick Sink, may be related to other processes, DOE believes and EPA concurs that gravity foundering is the most likely cause of the deformational features around the WIPP site. These features are created by the "sinking" of more dense anhydrite and subsequent "rise" of halite, resulting in deformed beds and domal-like structures. Not all of the domal features have associated brine pockets, and Borns, Barrows, Powers and Snyder (1983, A-93-02, II-G-1, Ref. 79) speculates that the brine pockets develops in areas of "anomalously high water content" (p. 88, Ref. 79). Jones (A-93-02, II-G-1, Ref. 342) states "Spatially the intraformational folding of the salt and anhydrite appears to be confined to a single long northwesterly-trending belt, about 3-

4 miles wide, that more or less coincides in trend and extent with the prominent southeastwardly plunging trough at the base of the Castile." This trough extends along the northern and eastern portions of the Delaware Basin into Texas and air drilling would be avoided from a technical perspective in these areas. EPA has no evidence to indicate that deformational features and associated pressurized brine pockets are present in the southern portions of the Delaware Basin to the same extent as may be present in northern portions of the basin. This may have a geologic origin, as salt horizons withing the Castile significantly thin to the south, removing one of the prime prerequisites of gravity foundering (salt). Given this, EPA concludes that the likelihood of brine pocket development is higher in the northern portion of the Delaware Basin.

The use of air to drill into the Castile Formation is unlikely considering the minimal ability of the technology to deal with high pressure formations. This necessitates the costly procedure, of switching from air to mud drilling twice before the hole through the salt section is completed. To drill with air from the ground surface through the Salado, the driller would have to follow the costly process of switching from air to mud at the bottom of the Rustler Formation to place and cement the casing needed to protect the salt section from dissolution by water inflows from the Culebra and overlying formations, switching back to air to drill through the Salado, and then switching back to mud to drill through the Castile.

The Agency considers the foregoing observations to corroborate the information cited above from industry contacts explaining why air drilling has not been commonly used in the Delaware Basin. Based on the technological capabilities and economic conditions at the time the CCA was prepared, the scarcity of successful air drilling in the Delaware Basin and the lack of air drilling near the WIPP Site indicate that most drillers were unwilling to risk the delays, cost, and safety hazards of drilling with air in an area with the potential for excessive water inflows, unstable formations, and high pressure brine reservoirs, when any one of these problems could require abandoning air technology and switching to mud.

6. SPALLINGS RELEASES DURING AIR DRILLING

An Agency concern associated with the air drilling scenario is that the lack of a mud-filled borehole may result in greater spallings releases if a waste panel is inadvertently penetrated. Spallings releases were found in WIPP performance assessment to constitute a significant fraction of total repository releases when inadvertent intrusion is presumed to occur, and significant increases in spallings releases could potentially cause the regulatory limits to be exceeded.

EPA examined the potential effects of air drilling from two perspectives. First, EPA assumed that air drilling did occur and estimated its effect on spallings releases. EPA found that even if an unrealistically high spallings release from air drilling did occur it still would not greatly affect spallings releases estimated in the CCA. Second, EPA modeled the potential consequences of air drilling using a spreadsheet model that could be modified to use air as the fluid instead of mud.

Results of this modeling indicate that only insignificant volumes of spalled material would be released due to air drilling.

EPA statistically examined the possible mean release volume of spalled material that could occur if air drilling took place. Public comments have suggested that the spalled waste volume from air drilling would be larger than the 0.5 to 4.0 cubic meters determined by DOE for mud drilling. Even if the total possible release volume from a drilling event is assumed to be as high as asserted by some public commenters (such as about 50 cubic meters), the calculated mean release volume is still relatively low when coupled with the low probability that such an event might occur. To arrive at this conclusion, EPA assumed that: 1) the mean release volume based upon the 0.5 to 4.0 cubic meters, uniformly distributed, is 2.25 cubic meters (releases of zero are ignored for this analysis even though there would be some modeling realizations where zero releases could occur); 2) less than 2.34% of the total wells in the Delaware Basin are air drilled; and 3) the total spalled volume is roughly equal to the maximum volume cited by testifiers in the January 5-9, 1998 WIPP hearings (50 cubic meters). The mean release volume, assuming air drilling, was then derived using the following:

$$MRV_{air} = MRV_{mud} (1-p) + Vp$$

where:

MRV = mean release volume
p = probability of air drilling
V= spalled volume

This calculation indicates that the mean release volume assuming air drilling at the determined probability yields an average release volume of approximately 3.4 cubic meters, which is more than the average release volume associated with mud drilling but still within the range of possible mean release volumes identified by DOE in the CCA.

To further address the consequences of air drilling, the Agency evaluated multiple modeling options. The Agency evaluated the modeling done previously by the Agency for the certification rulemaking. EPA decided that this modeling was inadequate to bound the impact of an air drilling event (Documented in Docket A-93-02, III-B-10 and II-B-11).

The Agency also reviewed the modeling work documented by Sandia National Laboratories (SNL) in SAND97-1369, *Spallings Release Position Paper: Description and Evaluation of a Mechanistically Based Conceptual Model for Spall* (Docket: A-93-02, II-G-23) to see if these models could be adapted to evaluate the air drilling scenario. Two models were considered, the Cavity Growth Model (i.e., the GASOUT computer code) discussed in Section 3.3 of the SNL report (Docket: A-93-02, II-G-23) and the Quasi-Static Model discussed in Section 3.4 of the SNL Report. Because of extreme code design limitations the GASOUT computer code could not be used to evaluate the impact of an air drilling event because the code would produce erroneous

results. Spallings releases calculated using air as the fluid in the GASOUT code are not valid because the code is not designed to be used with air as the fluid (See Docket A-93-02, IV-E-9).

The second model evaluated was the Quasi-Static model. The Quasi-Static model is a bounding simplification of a mud drilling scenario in the form of a spreadsheet model and has the versatility to simulate an air drilling scenario (See Appendix A of this report). It predicts the expected failed waste volumes during a drilling event in a repository waste room. The Agency reviewed the theoretical basis for the model, duplicated the calculations performed by SNL, and verified the modeling application and results documented by SNL in this report. Next the Agency adapted the input parameters of the borehole drilling fluid to those of an air drilling scenario. Then the Agency simulated the impact of an air drilling event and estimated failed waste volumes. (For more detailed documentation on the Quasi-Static Model see Docket A-93-02, II-G-23, page 3-23.)

The results of the Quasi-Static calculation are bounding and conservative. This is because the Quasi-Static model predicts the waste volume that has failed (i.e., is available to be transported) because of the dynamics of the air drilling event. Waste material that has failed must also be transported to the surface through more than two-thousand feet of borehole. Therefore, the Quasi-Static model over-predicts the volume of waste expected to be transported to the surface during an air drilling event.

The model predicted waste failure volumes on the order of 1.4 m^3. These volumes are within the values predicted by the CCA and used by the PAVT evaluation. Based on its conservative modeling analysis, the Agency concludes that air drilling need not be considered in the CCA.

7. AGENCY CONCLUSIONS ON AIR DRILLING ISSUES

In its certification application, DOE identified the use of mud as the fluid for well drilling as the current practice in the Delaware Basin. The Agency accepted DOE's contention. However, public commenters have raised the issue that air drilling may occur in the Delaware Basin and releases from such an event could potentially cause WIPP to fail the numerical containment requirements at 40 CFR 191.13. EPA examined the air drilling issue from several perspectives. This report has discussed EPA's effort to determine the prevalence and use of air drilling, EPA's review of the regulatory requirements for the consideration of air drilling, and EPA's estimate of the potential consequences to spallings releases if air drilling did occur at WIPP.

EPA has identified, through a random search of 203 well records from the New Mexico portion of the Delaware Basin, that air drilling is not a common practice. Only one of the 203 well records had any indication of the use of air (in 1958), but the records did not identify whether the well was actually drilled. In addition, EPA contacted 25 individuals knowledgeable about drilling in the Delaware Basin. These industry contacts indicated that, while they knew of air drilling outside of the Delaware Basin in New Mexico and Texas, they were generally not aware of air drilling being used in the Delaware Basin. These individuals indicated that technical and economic difficulties were probably the reason for the lack of air drilling in the Delaware Basin. These

independent lines of evidence indicate to the Agency that air drilling, and especially air drilling through the salt section, is not consistent with current practice. This was confirmed by a separate analysis of 3349 wells in the Delaware Basin (Docket: A-93-02, IV-G-8).

While 40 CFR 194.32(a) requires that drilling be evaluated in the WIPP performance assessment, 40 CFR 194.33(c)(1) identifies that future drilling practices are assumed to be consistent with drilling practices at the time the certification application was prepared. EPA has identified that air drilling through the salt section (where the waste is included) is not consistent with current drilling practices. Therefore, on regulatory grounds, the WIPP performance assessment does not need to include air drilling into the repository over the 10,000-year regulatory time-frame. Furthermore, under 40 CFR 194.32(c), performance assessment does not need to include potential releases from air drilling in the near future, since there are regulations currently in effect which prevent the use of air drilling in the vicinity of the WIPP.

However, in an effort to thoroughly understand all aspects of the issue, EPA has conducted an analysis of the potential consequences of air drilling. EPA assumed that spallings releases would be 50 m^3, as suggested by public comments, and that air drilling would occur about 2% of the time, as indicated as the upper bound from EPA's random survey of drilling practices in the New Mexico portion of the Delaware Basin. Using this very high volume of material assumed to be released from an air drilling event, the expected volume of material released is still low (3.4 m^3). EPA also explicitly modeled a potential air spallings release and identified that an individual release would be similar to that of a release calculated assuming mud as the drilling fluid.

EPA concludes that because it is not a current drilling practice in the Delaware Basin, air drilling does not have to be included in the WIPP performance assessment. Furthermore, based upon analysis, EPA expects the impacts of air drilling to be minor and within the range of releases used in the compliance certification application.

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ATTACHMENT 1. EXAMPLE OF DATA TABLES, EPA RANDOM WELL SEARCH

Well Name and API Number	**Well Coordinates and Location (T/R, Section, footage/ quarter, State County)**	**Operator/ Contractor(s)**	**Inside Potash Exclu-sion Zone? Y/N (if Y, select new well)**	**Stratigraphy and Formation Tops and TD; indicate target horizon**	**Casing Strings; diameter, depth set, cement**	**Drilling History Synopsis and well status (i.e., producing well, P&A, etc.)**	**Type of Fluid Used in Hole and Intervals (Specifically Identify fluid used to drill Salado)**	**Comments**
30-015 27753 Poker Lake No. 83	T24S,R31E, Section 30, NW of the NW quarter, Eddy County	Bass Enterprises	N	TD: 8300 ft Top of Salt Section: 895 ft Base of Salt Section: 4037 ft Delaware Basin (Group) 4228 ft	11 3/4 inch to 843; 470 sacks of cement. 8 5/8 inches to 4150 ft; 1220 sacks of cement. 5 ½ inches to 8300 ft; 810 sacks of cement.	Oil well, with production zone at 7956 ft-7966 ft; potential production: 272 barrels of oil per day. 337 million cubic feet of gas/day. 144 barrels of water per day also produced. Delaware is producing horizon.	Brine/water used to drill from 900 to 4200 ft.	Completion date: 3/25/94 Mud program proposed was proposed for drilling from surface to total depth. Rotary tools used.